News from ISOLDE and HIE-ISOLDE

ISOLDE today
- Beams
- Setups
- Physics examples

Future projects
- HIE-ISOLDE
- TSR@ISOLDE
- MEDICIS

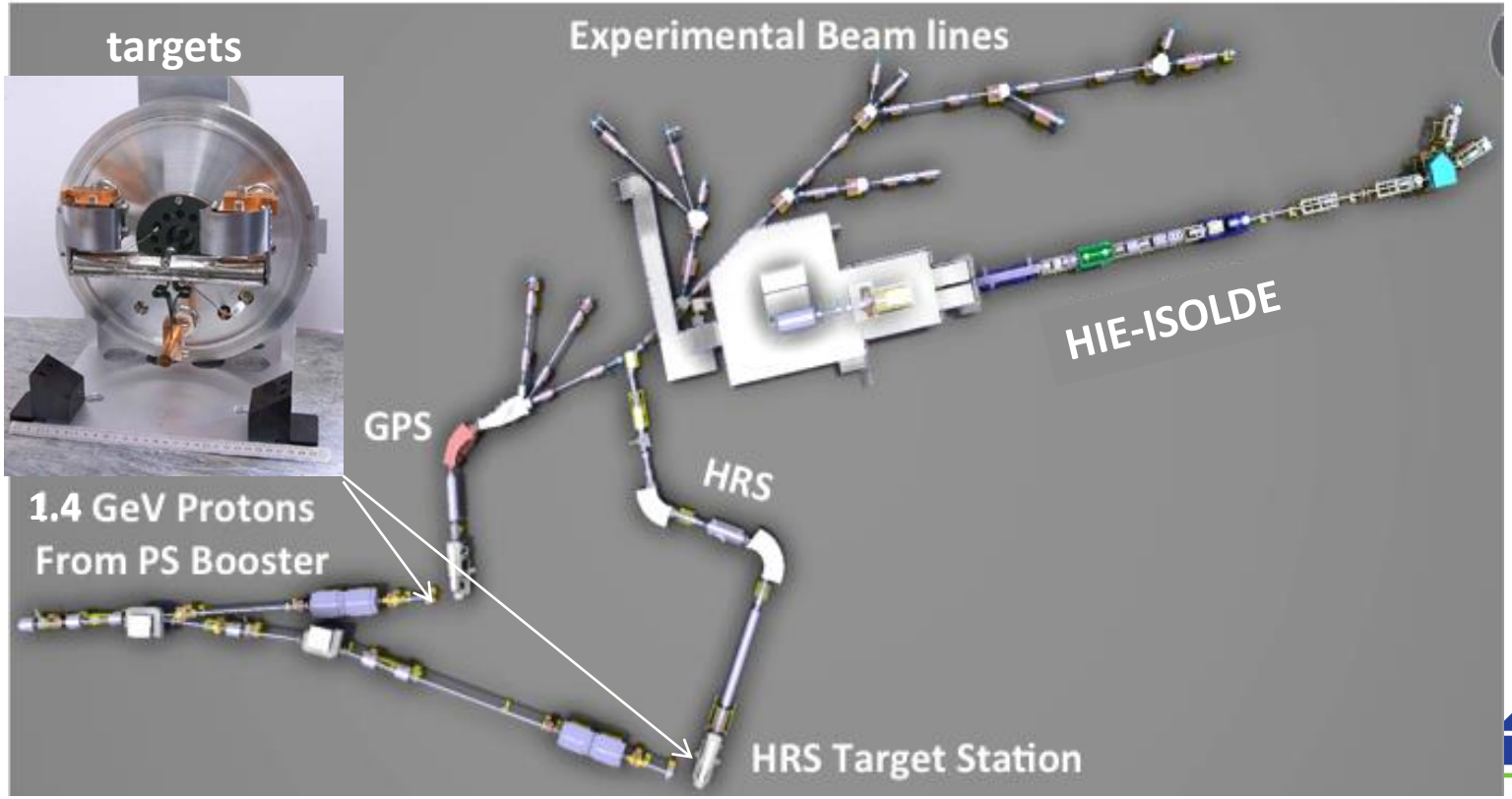
Summary

Magdalena Kowalska
ISOLDE Physics Coordinator

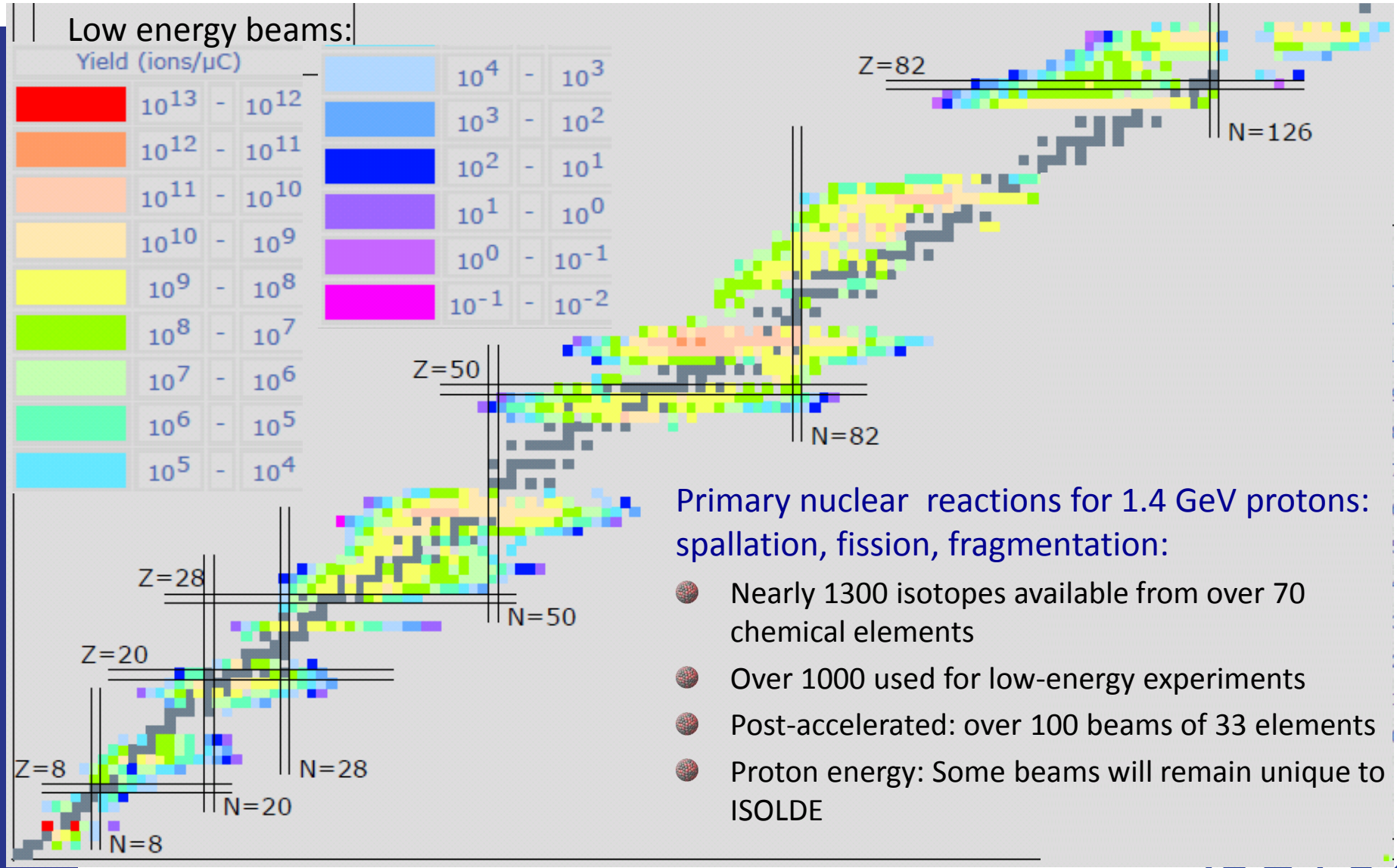
ISOLDE Facility

- CERN Radioactive Ion Beam facility
- The first ISOL-type Nuclear Phys Lab
  - 1st beam 1967, new facility 1992 @ PSB
  - HIE-ISOLDE upgrade approved in 2010
- Running 8-9 months per year
- 50 experiments per year

- 30-60 keV and MeV/u ion beam
- eV energy spread and small emittance
- Possibility to bunch beam (μs bunches)
- High beam purity (e.g laser ionization)



ISOLDE delivered beams



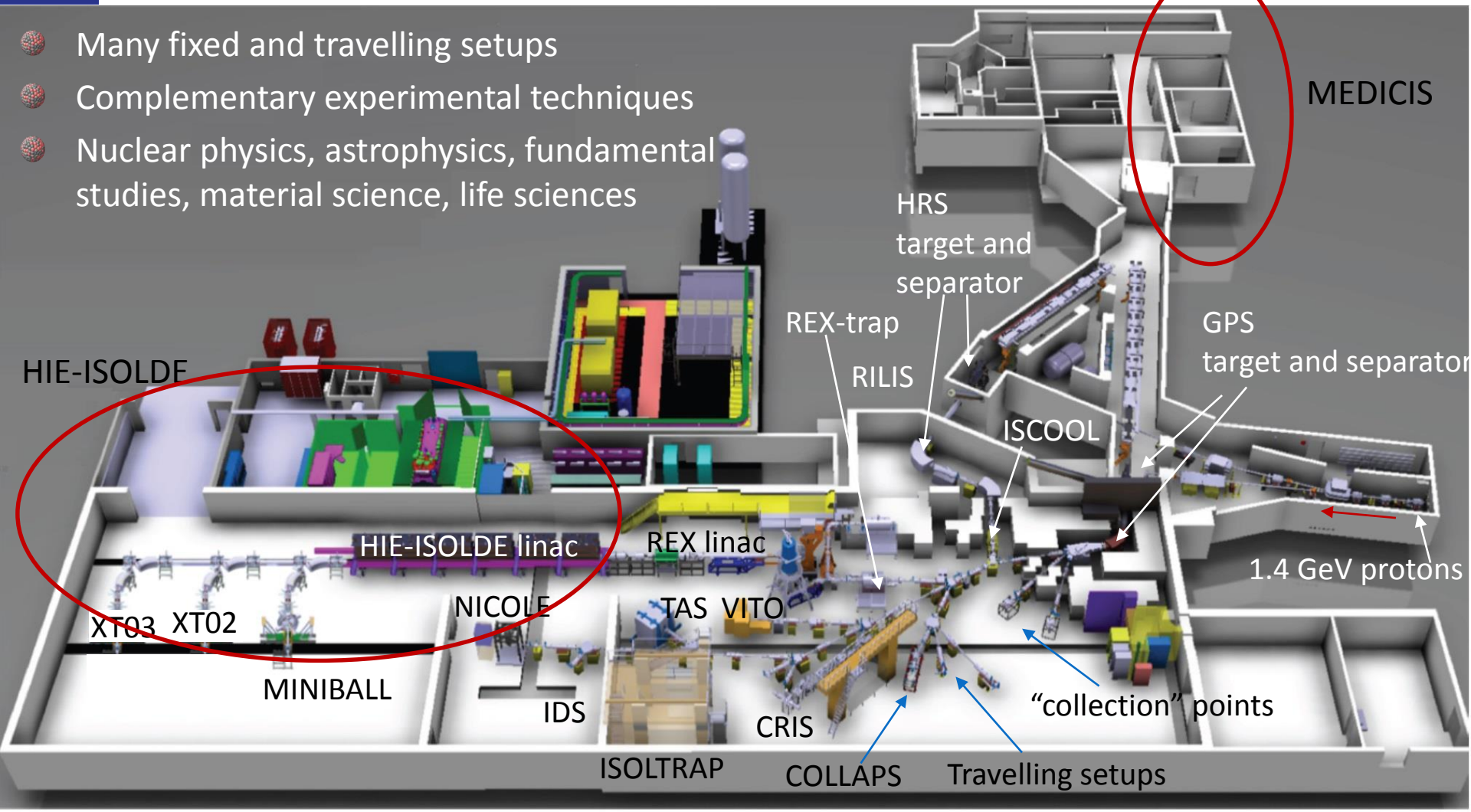
Primary nuclear reactions for 1.4 GeV protons: spallation, fission, fragmentation:

- Nearly 1300 isotopes available from over 70 chemical elements
- Over 1000 used for low-energy experiments
- Post-accelerated: over 100 beams of 33 elements
- Proton energy: Some beams will remain unique to ISOLDE

Users want even more beams and at different energies

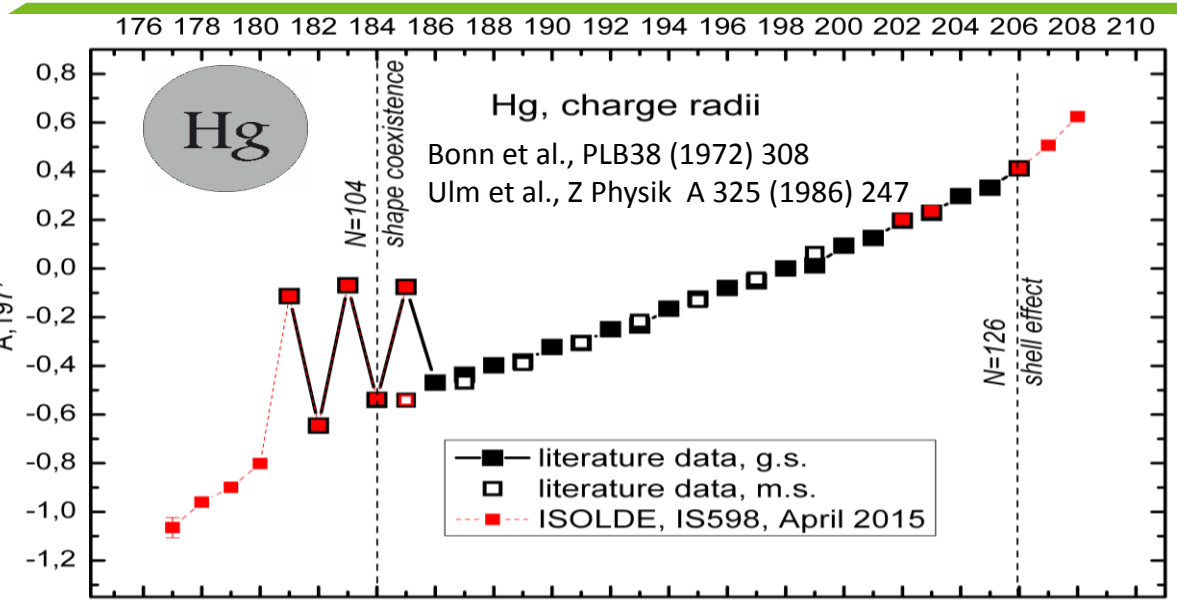
ISOLDE present layout

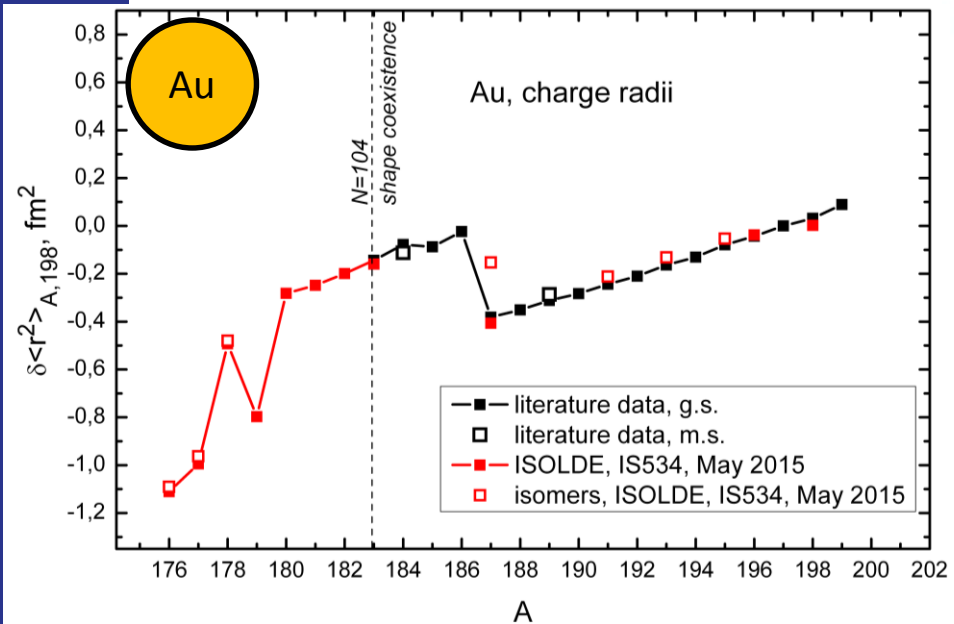
- Many fixed and travelling setups
- Complementary experimental techniques
- Nuclear physics, astrophysics, fundamental studies, material science, life sciences



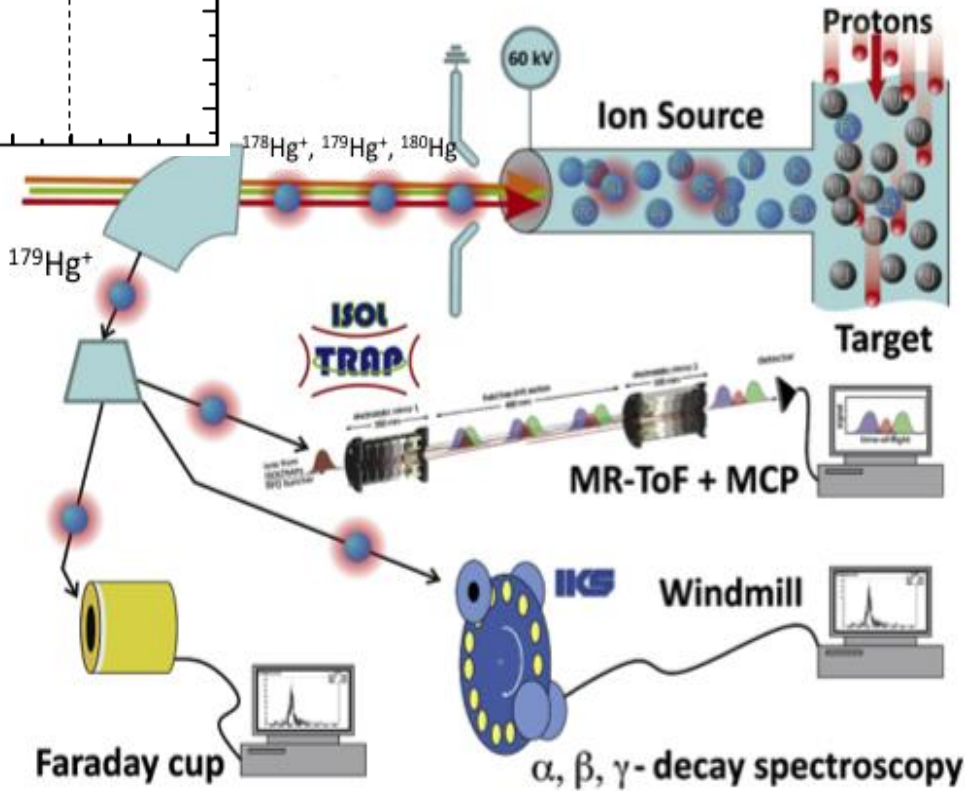
Physics experiments: n-def Hg & Au isotopes

RILIS, Windmill, ISOLTRAP teams

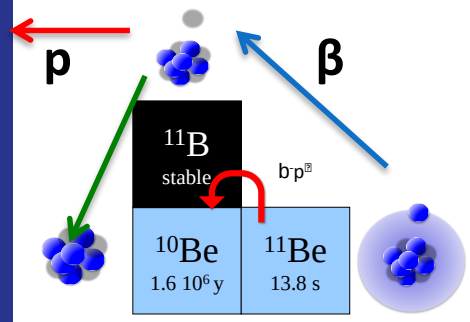




- Several techniques combined
- RILIS lasers to probe the hyperfine structure of Hg & Au isotopes
- Detection:
  - Alpha spectroscopy with Windmill
  - Selective ion counting in MR-ToF



Physics experiments: ^{11}Be βp emission

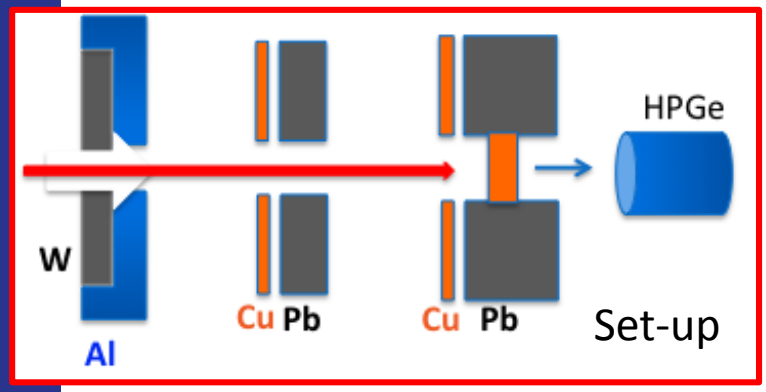


- ^{11}Be best case to search for βp, $Q_{βp}$ = 280.7 keV
- Expected B.R. = 10^{-8}, assuming direct decay
- Previous attempt gave unconclusive result with BR = 2.5(25)x10^{-6}

- Need to have good control over background:
  - HRS: Isobaric, and close-A contaminants, e.g. 11Li, 10Be
  - RILIS selectivity: Be lasers on/off

Dec 2012
May 2015

A 200 keV 10^{-8} proton branch is challenging to detect → Detect ^{10}Be daughter by AMS



- Contaminations measured to be negligible

- B.R. = 8.4(6) x 10^{-6} Consistent with previous results
- New Resonance identified in ^{11}B
- More systematic studies in May 2015

Physics experiments: medical isotopes

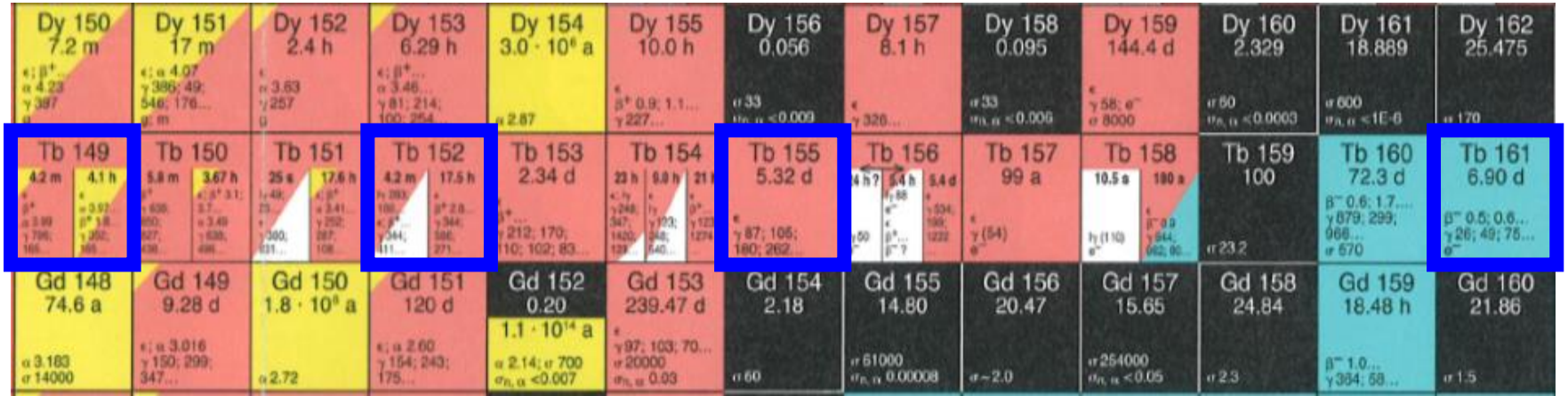
2012
2014
2015
Soon at MEDICIS

U. Koester and PSI team

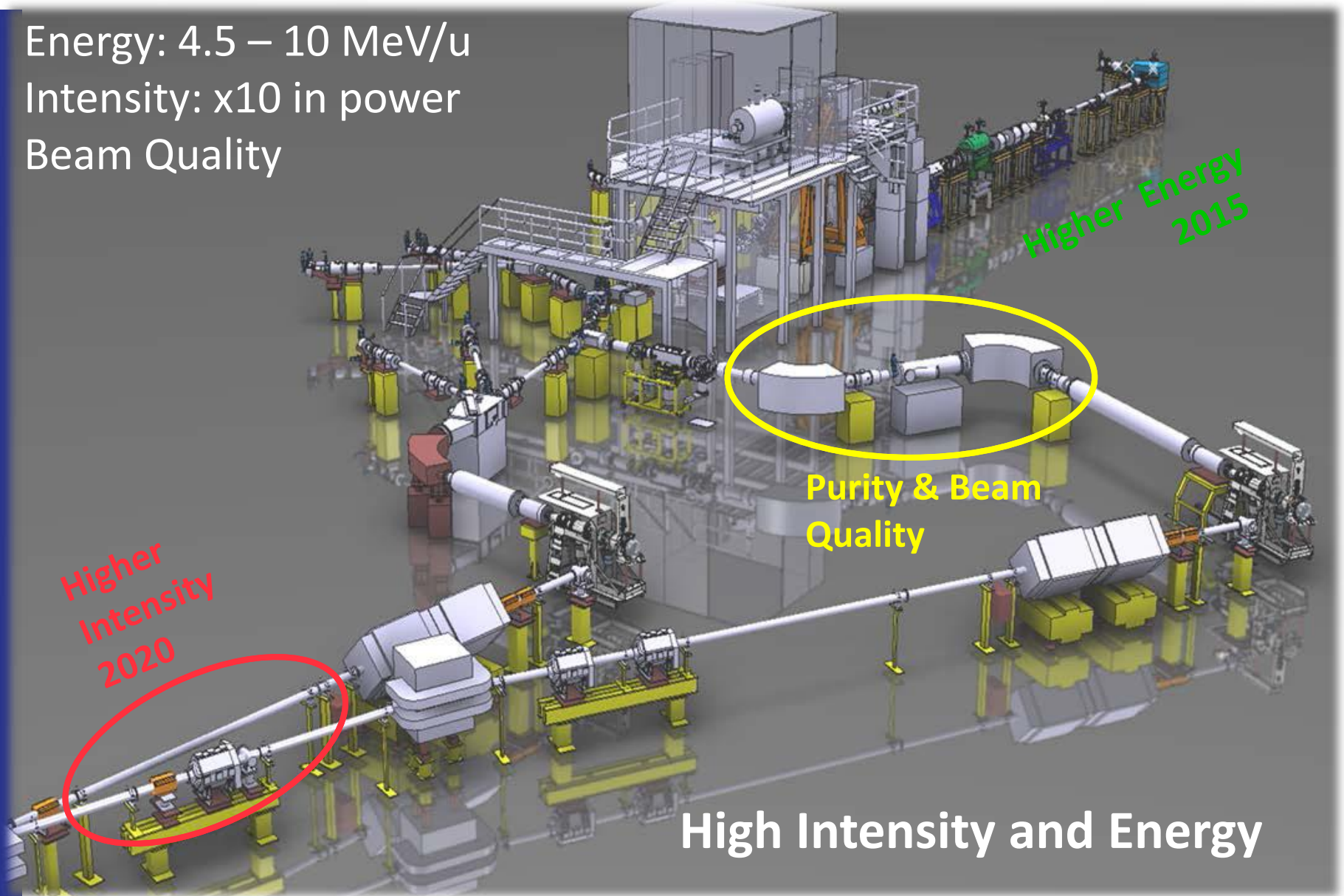
- Theranostics = therapy and diagnostics together
  - Production of isotopes at ISOLDE
  - Chemical selection and mice treatment in PSI

^{149}Tb: targeted alpha therapy. 2014 tests establishing safe usability limits, e.g. kidney damage

^{155}Tb: Very promising results about the effect of Auger electrons for therapy



Upgrades: HIE-ISOLDE project



Increase in beam intensity due to p beam

Yield: $Y = I \times \sigma \times \varepsilon_{rel}\,\varepsilon_{ion}\,\varepsilon_{sep}\,\varepsilon_{transp}$

Efficiencies (release, ionization, mass-separation, transport)

Proton beam intensity

Target thickness

Production cross section (depends on p energy)

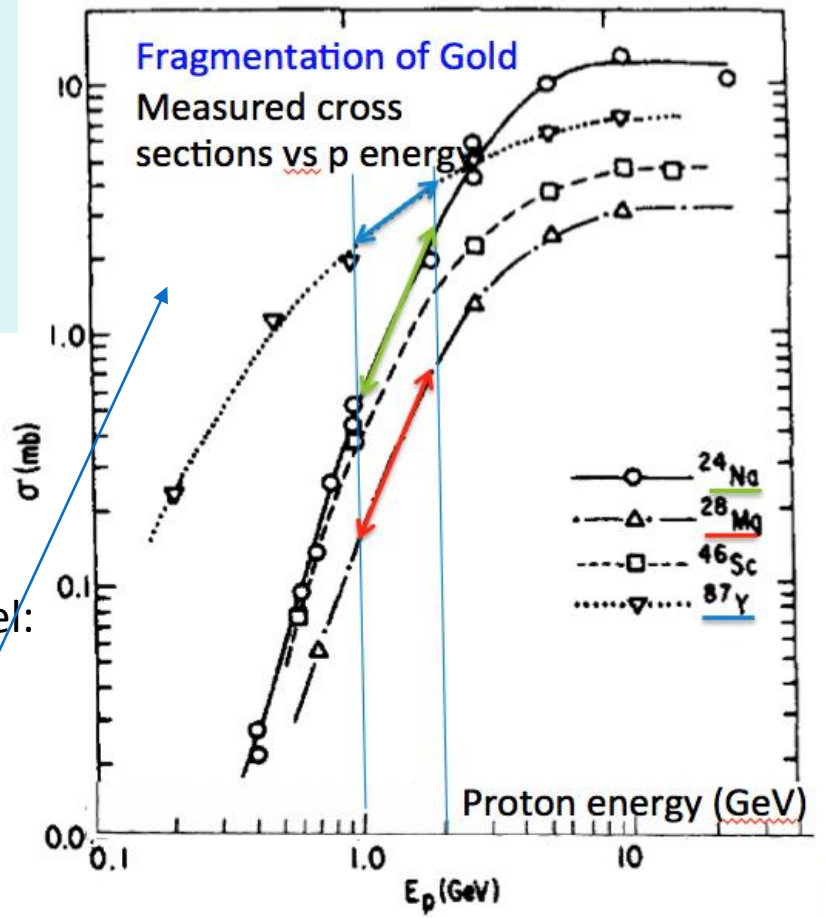
Higher proton intensity:
PSB upgrade & LINAC4 ($1x10^{14}$ p's/bunch, now $3.3x10^{13}$): in Long Shutdown 2 (2020)

Possible proton energy increase:
2GeV p energy (now 1.4 GeV): option, LHC Injector Upgrade: in LS2 (2020)

Intensity increase:
linear increase in production in all 3 channels

Energy increase:
Production increases differently for each channel:

- Fission – proportional to 2/1.4
- Fragmentation: 2-5 increase
- Spallation – large effect > 5



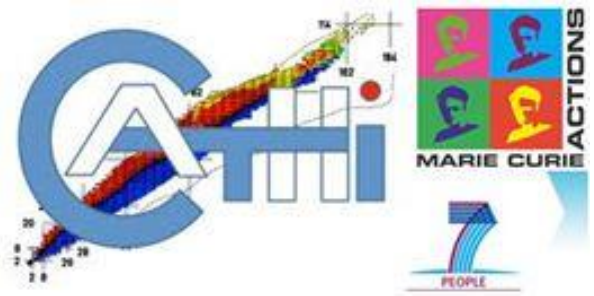
HIE-ISOLDE Design Study

Intensity Upgrade

- Thermal Studies
- Target Material Studies
- Fluka Simulations
- Cooling & Ventilation renew
- Frontend
- High Voltage
- Beam Dumps

Beam Quality

- Vacuum
- New RFQ Cooler
- REXEBIS Upgrade
- Off-line Separator
- New High Resolution Separator



Big help via **EU ITN called CATHI** – 20 young researchers, part of whom worked on the above topics

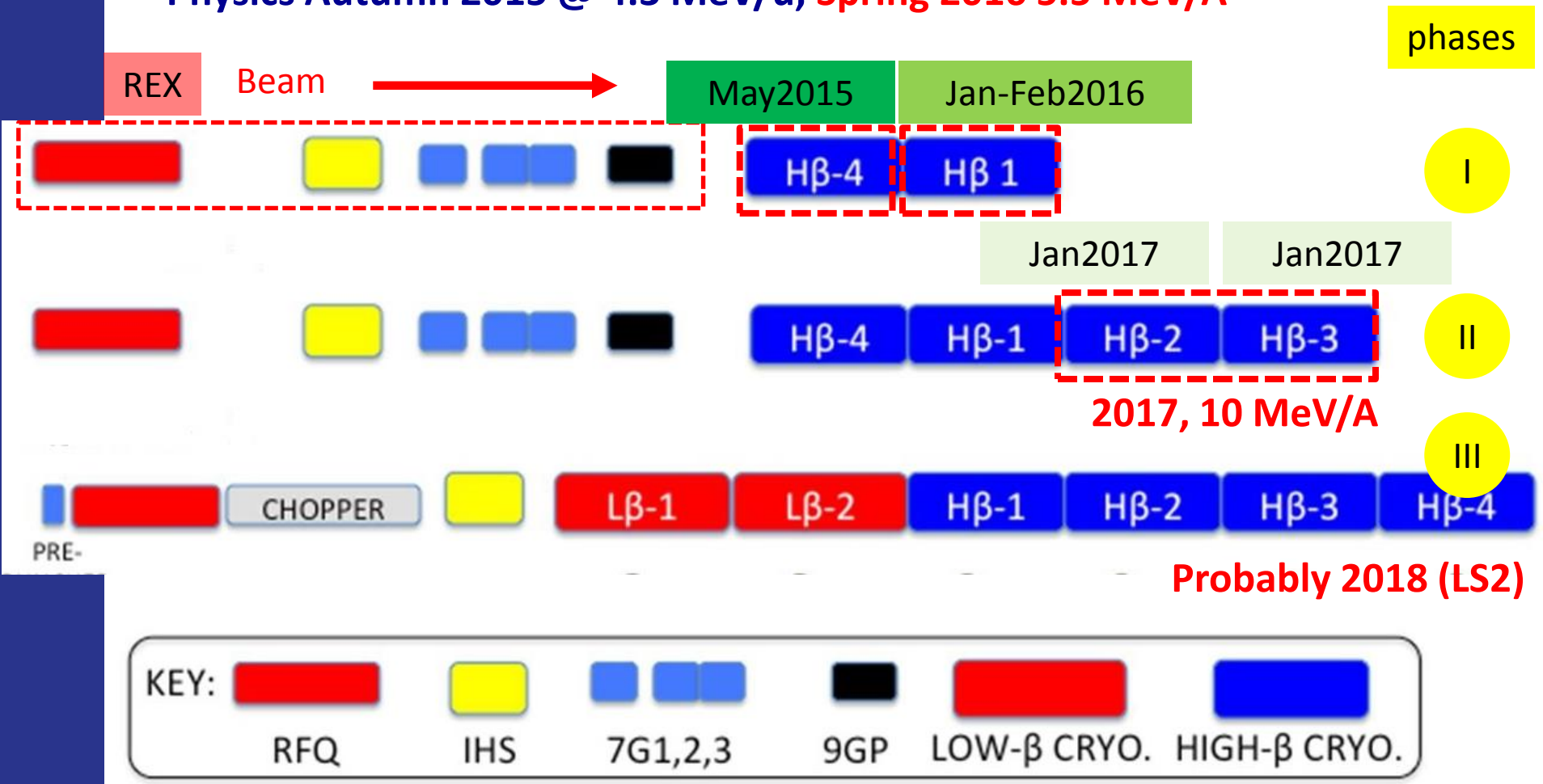
Timescale:
Design study: 2011-2014
Implementation: started for some points

R. Catherall et al

HIE-ISOLDE Energy upgrade: SC-LINAC

- Superconducting linac, Installed behind REX linac, Mounted in 3 stages

Physics Autumn 2015 @ 4.3 MeV/u, Spring 2016 5.5 MeV/A



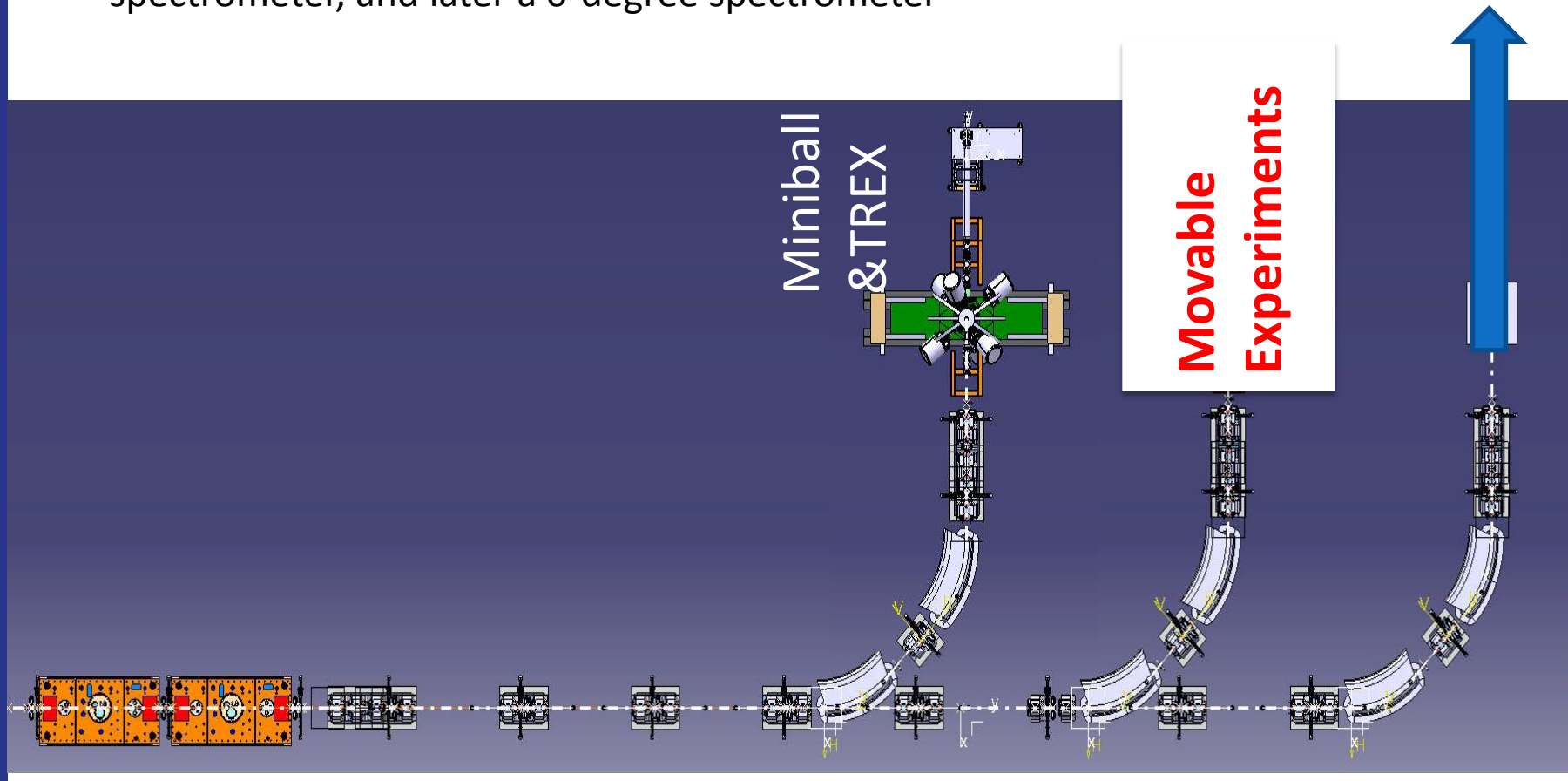
HIE-ISOLDE status

1st Cryomodule being cooled down in ISOLDE since last week

Getting ready for physics in October 2015

Physics beamlines

- In phase I: 2 experimental stations:
  - Fixed: MINIBALL + ancillary detectors: T-REX, SPEDE,
  - Travelling experiments and other setups: REX scattering chamber, beta-NMR setup
- At some point in phase II: 3rd beamline – U-shaped, for HELIOS-type spectrometer, and later a 0-degree spectrometer



First experiments at HIE-ISOLDE

- Collectivity versus Single Particle
- Shape Coexistence

Experiments planned for 2015

MINIBALL: Choice of experiment:

-Viability

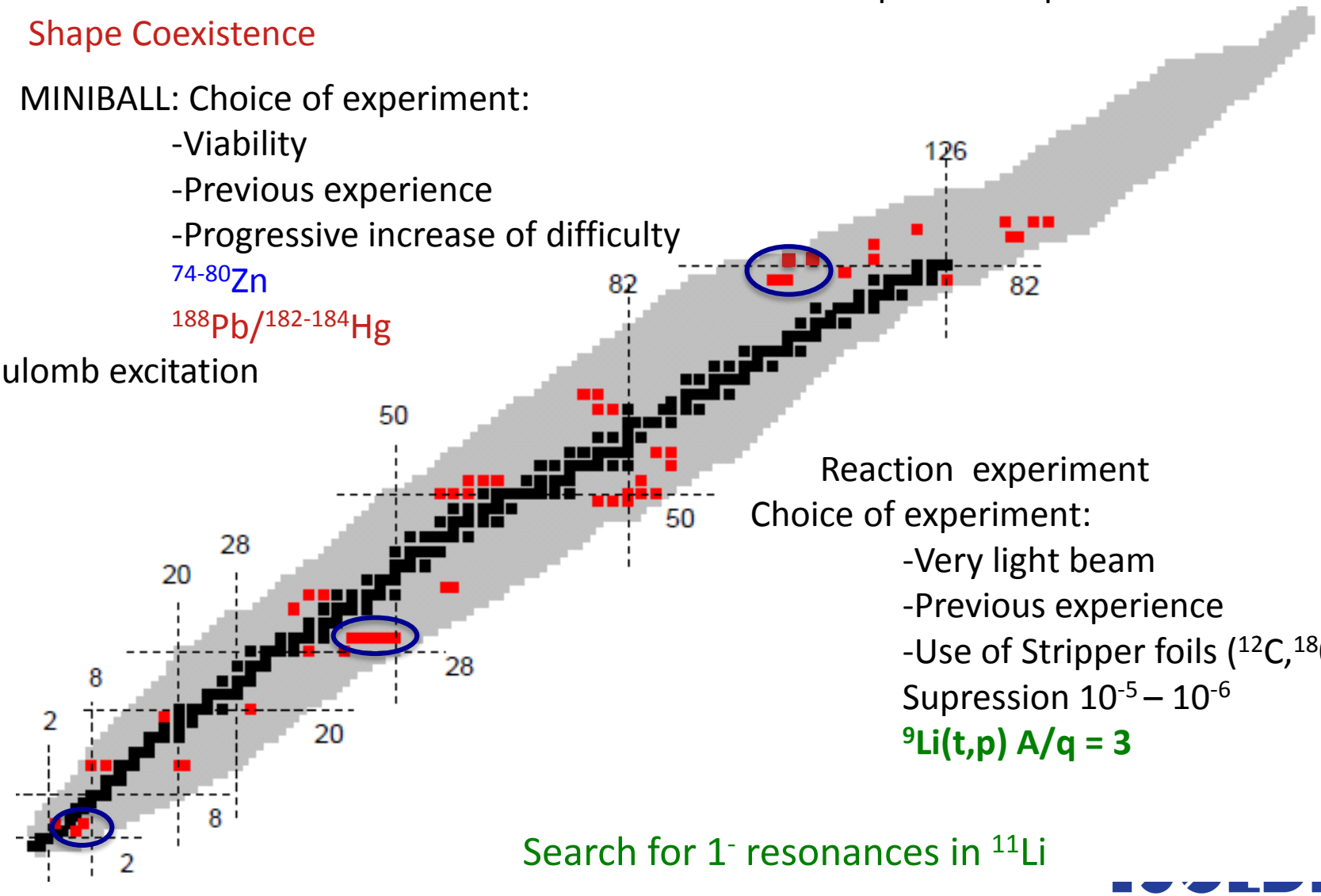
-Previous experience

-Progressive increase of difficulty

$^{74\text{-}80}$Zn

^{188}Pb/$^{182\text{-}184}$Hg

Coulomb excitation



Reaction experiment

Choice of experiment:

-Very light beam

-Previous experience

-Use of Stripper foils (^{12}C,^{18}0)

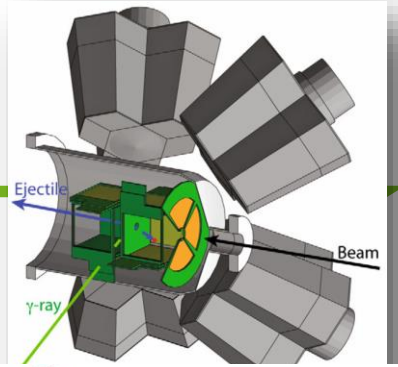
Supression 10^{-5} – 10^{-6}

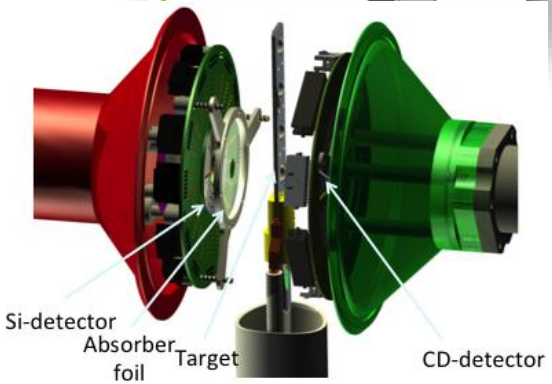
^{9}Li(t,p) A/q = 3

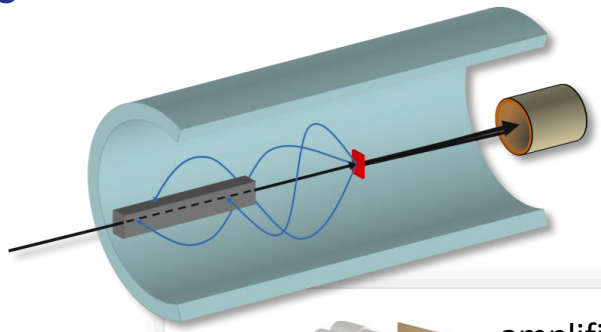
Search for 1^- resonances in ^{11}Li

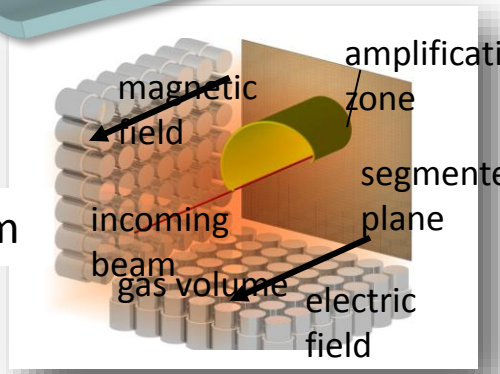
HIE-ISOLDE Instrumentation

- **Miniball + T-ReX (upgrade planned)** :
  COULEX + Transfer
- **SPEDE: added to Miniball+T-REX**
- **Multipurpose reaction chamber**
- CORSET chamber for Fusion-fission reactions
- **Helios type Spectrometer** (Hall →@ TSR)
- MAYA/ACTAR: resonant scattering + transfer
- **Zero-degree spectrometer**









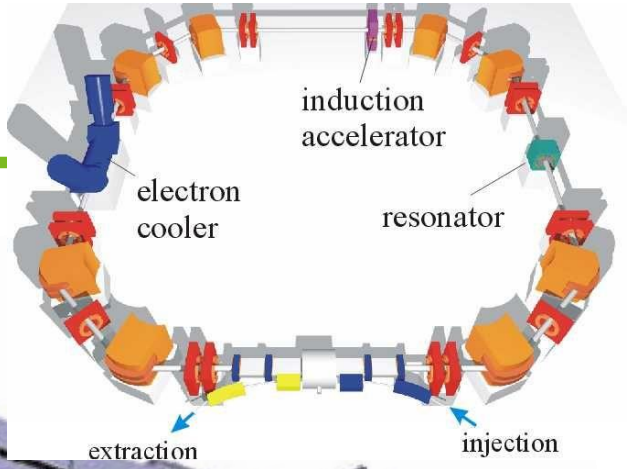
Devices belonging to collaborations who built them and maintain them

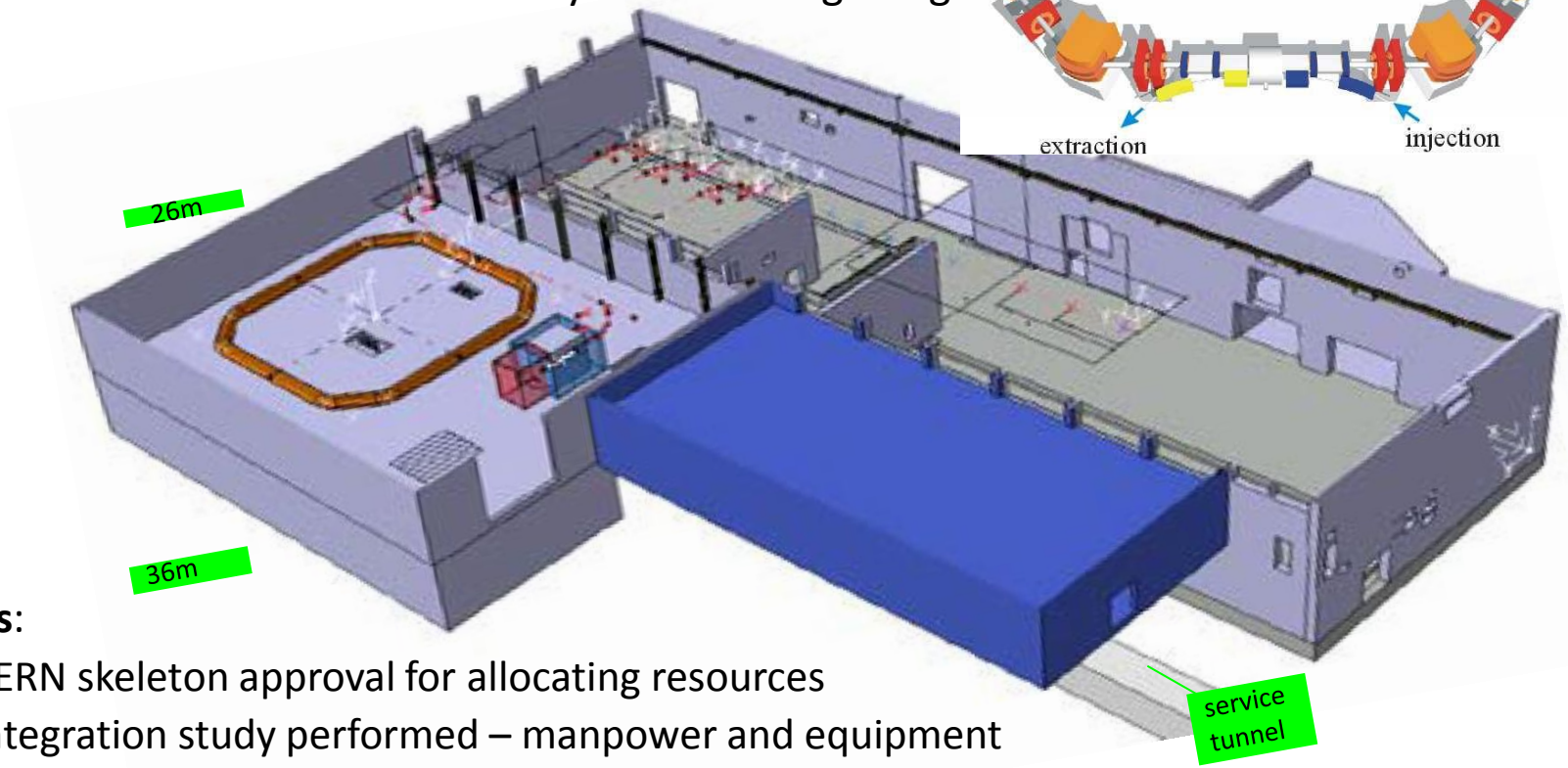
Legend:
existing/commissioned, in preparation, **stationed at ISOLDE**

TSR@ISOLDE

Test Storage Ring from Heidelberg

ISOLDE would become 1st ISOL facility with a storage ring





Status:

- CERN skeleton approval for allocating resources
- Integration study performed – manpower and equipment
- Aim: be included in MTP 2015-2019, **probable** timeline:
  - Building – before LS2 (CERN long shutdown 2, starting in 2018)
  - Installation and CERN-standardization of the ring – during LS2
  - Physics – after LS2 – 2020?
- External funding: UK grant, 4.8 MGBP

E. Siesling

Physics with TSR@ISOLDE

April 2015:
3rd TSR@CERN workshop

Advantages

With respect to in-flight storage rings

- High intensity
- Cooler beams
- Much faster

With respect to "direct" beams

- Less background (target, beam dump)
- Improved resolution
- CW beam

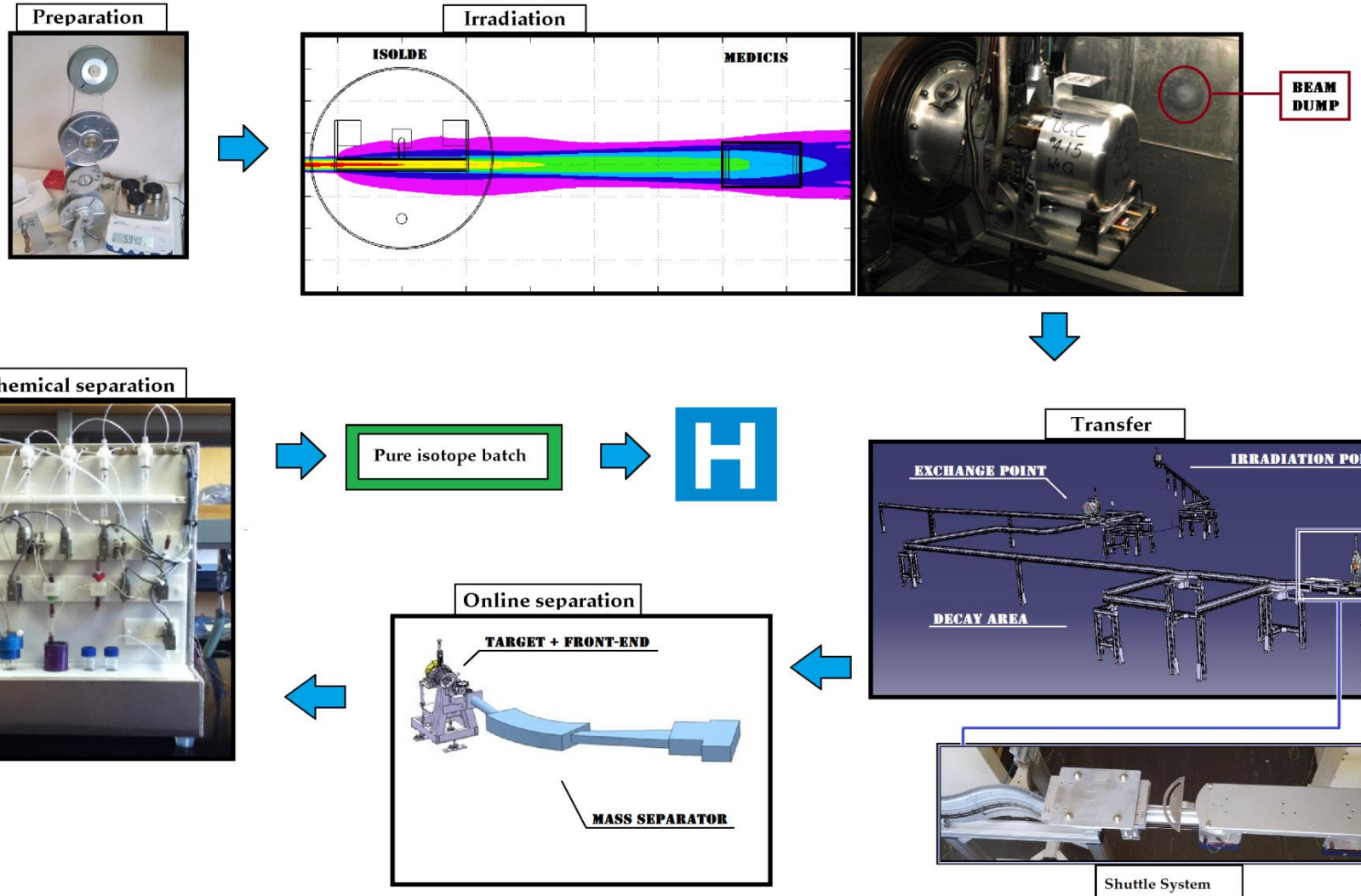
Physics programme

- Astrophysics
  Capture, transfer reactions
  ^{7}Be half life
- Atomic physics
  Effects on half lives
  Di- electronic recombination
- Nuclear physics
  Nuclear reactions
  Isomeric states
  Halo states
  Fission studies
  Laser spectroscopy
- Neutrino physics

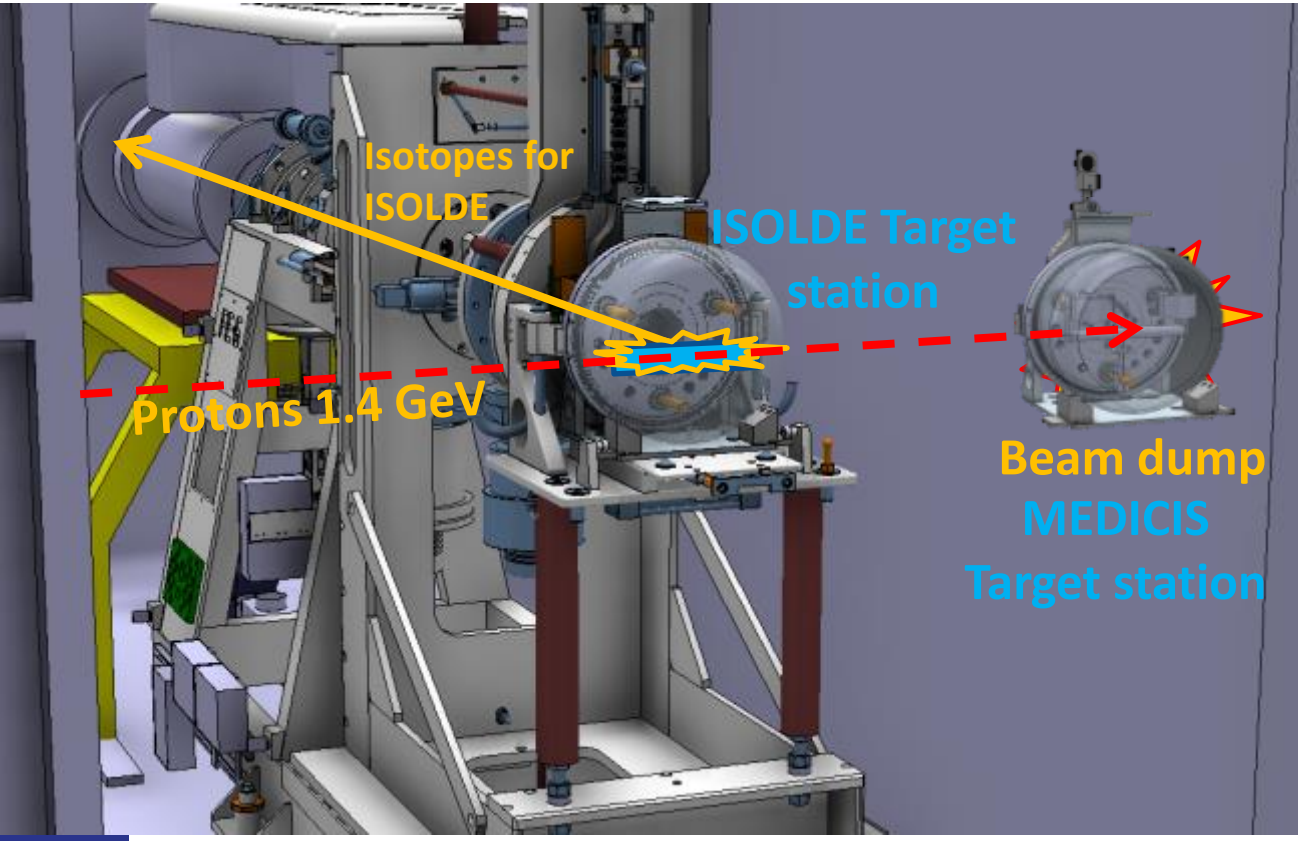
Applications: MEDICIS at ISOLDE

Production of medical isotopes for trials (not commercial use) via ISOLDE “dump” protons

-> little ISOLDE + chemical preparation



MEDICIS principle



Use protons (~90%) normally lost into the **Beam Dump**

1st isotope production: 2016
UC targets: 2018

Soon supported via EU ITN network MEDICIS-PROMED

To ISOLDE Jura side

To ISOLDE Saleve side

Summary

- ISOLDE has already provided a variety beams for many physics topics

- Aims to be competitive also in the future, via
  - HIE-ISOLDE upgrade
    - ✓ Increase in ion beam intensity
    - ✓ Increase in energy of post-accelerated beams
  - Spin-offs in applications: MEDICIS
  - Upgrades to existing and new experimental setups

=> All to allow cutting-edge physics